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Treatment of Khartoum North Industrial Area and Domestic Liquid Waste

A thesis Submitted in Partial Fulfillment of the requirements for the Degree of M. Sc. in Environmental Engineering

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ABSTRACT

This study evaluates the environmental impact of the liquid wastes discharged from the Khartoum North Industrial Area.

The analysis of combined wastes from the finishing operations covered the sanitary characteristic: BOD, COD, Oil & grease, total suspended solids.

The values obtained at finishing operations were compared to the permissible values in 1971 municipal Act.

The analysis indicated that the characteristics of wastes wastewater were largely polluted and over the permissible values. For this load Alhag Usif Treatment Unit plant not efficient for this strength.

Joint treatment with domestic sewages is the most suitable and economic method for this unit.

CHAPTER (I)

1. INTRODUCTION

1.1 General:

Pollution is an inevitable consequence of most human activity. The commission of the European communities [CFC, 1979] has put this note(1):

> [*Almost all human activities make some impact on the natural environment, and almost all industrial processes, which transform natural resources into products for man's use, give rise to some pollution. Acceptance of the reality of this situation is now general, although there are still some who call for a removal of all pollution, not realizing that this could signal the end of human activity, as well as of industrial civilization as we know it*].

The popular belief that pollution is getting worse, the available information indicates that trends vary greatly between individual pollutants. In general, acute local pollution has become very rare; where as widespread low–level pollution has been increasing recognized as a potential problem. Localized elevated pollution levels associated with particular industrial and other stationary sources still cause serious problems.

Various types of industries have come to existence; the important groups of them are[2]:

1. Apparel: Textile, leather goods and Laundry trade.
2. Food and Drugs: Canned foods, brewed and drinks, yeast–etc.
3. Materials: Pulp and papers, steel, oil fields and refineries, rubber, glass, wood processing, glue manufacturing–etc.
4. Chemicals: Acids, detergents, explosives pesticides, plastic and resins, phosphate and phosphorous–etc.
5. Energy: steam power, unclear power, hydroelectric, radio–active materials etc.
6. Others.

Industrial waste can be pre–treated to reduce the organic or inorganic solids prior to disposal in a municipal plant. Tannery or textile wasters may require pre–treatment by aeration to prevent acid malodorous influent wastewater.

Metal–plating wastes containing cyanide chromium, zinc, copper and other heavy metals may require treatment in addition to equalization if the toxic ions are not sufficiently diluted with domestic wastewater. Chemical treatment oxidation or coagulation is commonly used for removal of this inorganic pollutant. Wastes streams with high concentration of refractory pollutants {i.e. salt or ammonia nitrogen} must be regulated at the plant site if the municipal waste–disposal system does not have sufficient assimilative capacity.

An industry has three possibilities for disposal of process wastewater.

1. Wastewater may be treated separately in an industrial waste–treatment plant prior to discharge to a watercourse.

2. Raw wastewater may be discharged to the municipal treatment plant for complete treatment.

3. Industrial wastes can be pre–treated at site prior to discharge in the municipal sewerage system.

Careful study must be performed to determine the most feasible method of disposal[3].

Joint treatment of industrial and domestic wastewater has several advantages. The majority of industrial wastes are more amenable to biological treatment after dilution with domestic wastewater.

Three categories of wastes should be excluded from the municipal sewers those which create a fire or explosion hazard, or impair hydraulic capacity (e.g. paunch manure or sand), or create a hazard to people, the sewer system, or the biological–treatment system (e.g. toxic metal irons or petroleum wastes)[(4)].

Pre–treatment should be considered for industrial discharges, which have strengths or characteristic differing significantly from domestic wastewater. Only a fine line of difference may exist between an untreatable trade wash and the one which can be jointly treated after certain pre–treatment by considering the industrial process design, segregation of waste equalization of waste water and strength reduction[(3)].

A retention pond serves leveling out the effects of peak loading on the plant while substantially lowering the BOD and S.S. Air is some times is jested is to those basins to provide better mixing, for chemical and biological oxidation to prevent suspended solid from setting.

1.2 INDUSTRIAL POLLUTION CONTROL

Industry has the ability to enhance or degrade the environment; is extracts raw material from the natural–resource base and inserts both useful product and waste materials into the human environment.

Industrial activities produce different types of wastes in liquid, solid or gaseous forms, with different characteristics that may create adverse environmental effects when released into the environment. Therefore, adequate control measures are needed in order to reduce the amount of pollutants produced, or render them harmless within the acceptable limits that can be tolerated by the environment.

Pollution control can be explained as "system of measurements, criteria, standards, laws and regulation that are directed at the sources and causes of various forms of pollution and its effects in term of control prevention"(5).

Pollution control measures fall in two categories; those affecting the environment external to the plant, and the two main approaches to industrial pollution control are traditional approaches and pollution prevention.

Pollution prevention follows a natural hierarchy waste management options:-

- Reduce waste at the source.
- Reuse or recycle waste that is produced, preferably on site and directly back into the production process.
- Treat waste that cannot be prevented or recycled with the lap test technology to detoxify, remove, or destroy it.

1.3 THE STUDY AREA

The study area consists of:

- Khartoum North Industrial Area, and
- Alhag Yousif treatment plant.

1.3.1 Khartoum North Industrial Area

It is the main industrial area in the country, and is located in the middle of the residential area in eastern part of the city of Khartoum North.

There are more 300 industrial plants including food industries, textile, wood and wood products, paper and paper products and painting, chemical industries, metal industries, etc.

The area also includes many vehicle repair shops, and small workshops for furniture manufacturing.

1.3.2 Alhag Yousif Treatment Plant

The sewage treatment plant is situated about 8km to the east of Khartoum North Industrial Area. The plant has a design capacity of 3.6 MGD and was designed in connection with a two–phase construction scheme[(6)]:

- Phase one consisted of sewering the industrial sewage to the waste stabilization pond system. This was constructed in 1960 and started operation in 1967 and represents the ongoing system today.

- Phase two, which has not yet been implemented, entails sewering of the residential areas. The domestic sewage from these would be combined with the industrial wastewater before being introduced to treatment plant. The plant has been designed to treat the flow through primary treatment by means of screening followed by grit removal, sedimentation and secondary treatment by means of stabilization ponds. The treated water was expected to been used for irrigation of Kuku Agricultural Scheme.

1.4 SIGNIFICANCE OF THE PROBLEM

Alhag Yousif treatment plant was designed to accept both domestic and industrial effluent. At present only the industrial sewerage system is installed. This gives rise to many problems:

- Industrial wastes usually affect the sewerage collection systems and treatment plants by contributing loads in excess of the systems plant capacity.
- Some difficulties result from too much cooling or wash water, too much grease or oil on clarifier surface or in digester, too much for grit and sludge removal equipment, and too great inorganic load for secondary units.
- In some cases, poisonous or toxic wastes discharged to sewer systems completely upset the biological processes at the primary treatment plant.
- The flow is mainly industrial in nature and lacks sufficient nutrients to satisfy the requirements of the high demand carbonaceous BOD.
- The present practice undertaken (i.e. collection of industrial wastewater from industrial and feeding it to treatment plant) has a great potential for adversely

affecting public health by direct contact and also through contamination of groundwater.

1.5 OBJECTIVES

1.5.1 General Objectives

The general objective is to assess the existing situation and suggest remedial solutions.

1.5.2 Specific Objectives

- Evaluate the main effects of industrial wastewater.
- To determine the quantity and strength of main industries wastewater in Khartoum North Industrial Area.
- Calculate the waste strength for the joint treatment of industrial and domestic waste.

CHAPTER (II)

2. LITERATURE REVIEW

1.1 Industrial Pollutants:

Pollutants directly attributed to industrial processes may be categorized as physical, chemical, and radioactive.

2.1.1 Physical Pollutants

(a) **Color**: Colors result from dyes and from other industrial and processing sources. Among the industries, which commonly contribute to watercolor, are the pulp and paper, textile, tanneries, petrochemicals, and chemical industries. Such colors cannot be measured by the platinum–cobalt test standard. They should be represented only in concentration, which can be removed by the standard water treatment plant.

The criterion designated as permissible criterion for color in waters used for public water supply is 75 color units (Platinum–cobalt standard). A value less than 10 color units is the recommended "desirable criterion"(7).

Color removals are obtained by standard chemical precipitation methods with associated absorption by the precipitant of flocculent. Carbon adsorption can be applied to the more difficult color removal problems.

(b) Turbidity: In most cases suspended clay or silt, dispersed organics, and microorganisms cause turbidity. The common operations employed for the removal of turbidity are coagulation or flocculation, sedimentation, and filtration. For waters designated for aquatic life preservation, turbidity due to the discharge of wastes should not exceed 50 Jackson units in warm water streams or 10 Jackson units in cold water streams[(7)].

(c) Odor & taste: In general, odor in water is due to the presence of dissolved gases, such as H_2S, and the presence of volatile organic compounds. Taste is an important factor in that it may be a direct indication of dissolved organic salts of iron, zinc, manganese, copper, sodium, potassium, etc.

Taste and odor in water supplies may also result from natural phenomena such as decaying vegetation, algae or bacterial slime.

As in case of color removal, taste and odor may also be removed through processes for treatment or control of waste constituents.

2.1.2 Chemical Pollutants

Acids and/or Alkalis: Excessively acid or alkaline wastes should not be discharged without treatment. Control of effluent pH obviously requires adjustment of the hydrogen or hydroxyl ion concentrations. This can be affected by the addition of alkalis or acids as required.

(b) Toxic Chemicals: Both inorganic and organic chemicals, even in extremely low concentrations, may be poisonous to aquatic microorganisms. Almost all salts, some even in low concentrations, are toxic to certain forms of aquatic life. Copper concentrations as low as 0.01 to 0.05 ppm are toxic to bacteria and microorganisms(7).

(c) Oil and Grease: Oil and grease pollution may be the result of refining and industrial plant wastes resulting from the lubrication of machinery. Oil and grease should be absent from industrial effluents; virtually absent as permissible criterion and completely absent preferably. They obstruct passage of light through the water, retarding the growth of vital plant food.

2.1.3 Effects of Industrial Pollutants on Sewage Plants:

To remove pollution from industrial wastes a sewage–treatment plant must have sufficient capacity and of the proper type. Joint treatment of municipal and industrial wastewaters, which are amenable to treatment, may offer greater removal efficiencies, but economics will usually be the deciding factor.

Pollution characteristics of wastes having readily definable effects on sewers and treatment plants can be roughly classed as follows:

- Biochemical Oxygen Demand (BOD),
- Suspended solids,
- Floating and colored materials,
- Volume, and
- Other harmful constituents.

BOD is a measure of the dissolved oxygen in a water supply needed to dispose organic materials in a measured time and at a constant temperature (5 days period, at 20ºC). BOD determination is an important index of industrial pollution when organic material is deposited as an industrial waste in a receiving stream. In fact, organic material is the single largest constituent of industrial wastes.

Oxygen must be provided so that bacteria can grow and oxidize the organic matter. An added BOD load, caused by an increase of organic waste, requires more bacterial activity, more oxygen, and greater biological–unit capacity for its treatment.

Major problems may arise when high BOD industrial effluent enters municipal sewage plants. Clogging or corrosion of the sewer system, hydraulic overloading of the equipment, or overloading of the grit chambers, or screens are just a few of the attendant problems. Industrial wastes may reduce the efficiency of the settling tanks and solid removal. They may produce scum problems with high oil and grease content. In addition, certain toxic industrial wastes destroy microbiological population required to degrade sewages.

Suspended solids are found in considerable quantity in many industrial wastes, such as cannery and paper–mill effluents. Suspended solids in industrial waste may settle more rapidly or slowly than sewage suspended matter. If industrial solids settle faster than those of municipal sewage, sludge should be removed at shorter intervals to prevent excessive build–up.

Floating materials and colored matter are those such as oils, grease, and dye from textile finishing mill. A modern treatment plant will remove normal grease loads in primary settling tanks, but abnormally high loads of predominantly emulsified grease passing the primary unit (screens, grit chamber, and settling basins) into the biological units, clog flow–distributing devices and air nozzles.

Sewage treatment plants are generally not designed to remove color. Trickling–filter plants (in U.S.A., North Carolina) were removing 34 – 44% of the dye color in the effluent[7].

A sewage plant can handle any volume of flow if its units are sufficiently large. An industry with a relatively clean waste, such as condenser water, can usually discharge it, after cooling, directly into the receiving stream and thus avoid overloading the sewage treatment plant. On the other hand, it is found that even in small concentrations of solids in a large volume of wastewater will sometimes result in a significant total–solid load.

Industrial wastes may contain harmful ingredients in addition to the pollution load. Toxic metals ions (Cu^{++}, Cr^{++}, $CN^{\sim}$) interfere with biological oxidation by tying up enzymes required to oxidize organic matter.

2.2 SOURCES AND CHARACTERISTICS OF INDUSTRIAL POLLUTANTS

Chemical industries usually use huge amounts of water as manufacturing–process water and as cooling agent in the industrial processes.

The wet processes discharge large amounts of wastewaters containing organic and inorganic materials, whose presence in the surface waters, ground waters and soil (if effluents are discharged in open areas) creates a number of environmental problems.

The major industrial wastes produced from the chemical industries in Khartoum North Industrial Area will be considered in turn.

2.2.1 Textiles Wastes

Most of the textile mills in Khartoum North Industrial Area are integrated plants conducting spinning, weaving, and finishing. These sections are divided into dry process (spinning, weaving and knitting operations) and wet processes (sizing, desizing, scouring, bleaching, mercerizing, dyeing, printing, finishing). Textile wet processes are among the major industrial water users.

The wet processes discharge large amounts of polluted wastewater. The sources of pollution are mainly the processing chemicals, which are removed from the cloth and discharged as wastes. The wastes vary according to the material used and the different are processing routes. Here, in the Sudan, the material used is mainly cotton. Therefore, the pollutants sources and wastewater quantities, and treatment methods are restricted only to cotton fabrics.

The cotton is first carded, spun, spooled and warped, slashed (sized), drawn, and woven or knitted into cloth before being sent to the finishing mill.

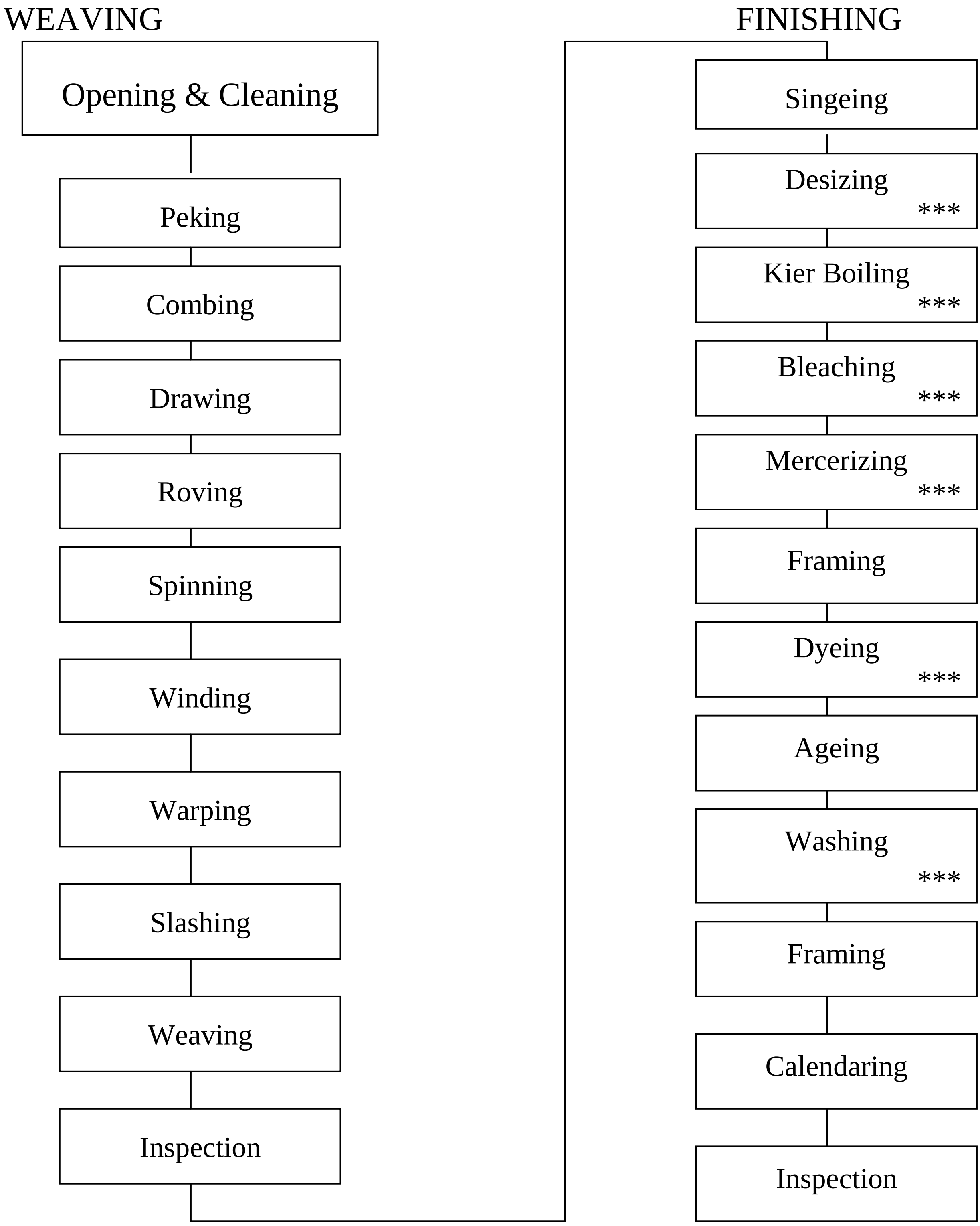
The finishing mill receives the woven cloth, which is further processed to satisfy different client demands. Fig. (2.1) shows cotton weaving processing flow diagram.

The weaving step entails mostly dry processing; the pollution problems resulting are predominately dust generation in the high–speed mechanical operations and a minimum amount of liquid waste from the spills and washout of the slashing boxes and the preparation of the size solution[(8)].

Each of the unit operations or processes performed on the cloth during finishing generates a liquid waste with its own peculiar character at each particular installation. The liquid wastes discharged contain organic and inorganic materials.

Inorganic materials in textile wastes may render water unsuitable for use because of excess conservation of soluble salts and because insoluble salts precipitate and deposit on streams bottoms, blanketing aquatic life[(9)].

Fig. 2.1: Cotton Processing Flow Diagram (1, 2)



*** wet processing

Organic compounds may undergo a gradual chemical or biological change which removes oxygen from the water, resulting in a septic condition characterized by odors, gases, floating solids, and generally disagreeable appearance. Some organic materials cause difficulties at sewage works because they are not easily degradable.

Some organic compounds are highly toxic to aquatic organisms even at concentrations of a few mg/l, e.g. ammonium compounds which are used extensively in textile industry as fabric softener, dye fixatives or water repellents[9,10]. Table (2.1) summarizes the types of chemicals used in textile–wet process[7,9].

Table 2.1: Chemical Used in Textile–Wet Processes:

Process	Chemicals
Sizing	Starches, carboxyl–methyl cellulose (CMC)
Desizing & Scouring	Acids, caustic soda, enzymes, soda–ash detergents and penetrants.
Bleaching	Chlorine, peroxides, sodium buisulfate, silicate.
Mercerizing	Caustic soda
Dyeing	Dyes and auxiliary chemicals, Dyes include: vat dyes, naphtols, sulphur dyes, basic dyes, indigo dyes, disperse dyes, pigments, and direct reactive dyes. Auxiliary chemicals: peroxide, chromate, acid, sodium nitrite, sodium bisulphides, acetic acid, tannic acid.
Finishing	Starches, dextrins, natural and synthetic waxes, ammonium and zinc chlorides, softening agents and penetrates.

Regarding textile effluents, the desizing and scouring processes contribute about 50%, the bleaching process 10% and the dyeing process 20 – 40% of the total pollution load(9).

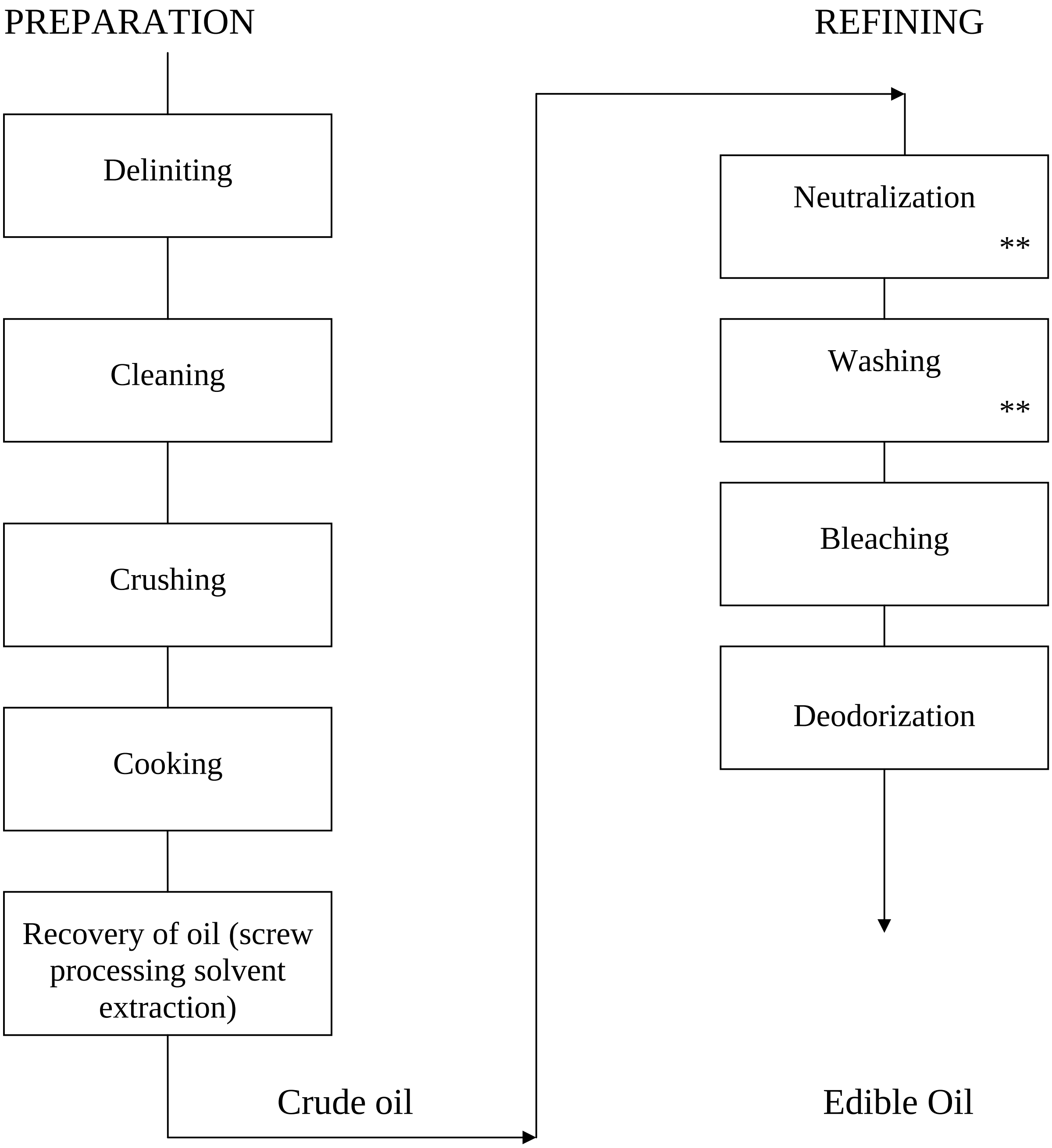
2.2.2 Wastes of Oil and Soap Industry:

2.2.2.1 Edible Oil Industry:

Oil and fats are referred to as lipids. They consist predominantly of triglycerides known as fatty acids. The individual fatty acids differ from one another in the length of hydrocarbon chain and in the number and position of double bonds in the chain. Other constituents are free fatty acids, phosphatides, sterols, hydrocarbons, and impurities as suspended matters.

The processing of edible oil (e.g. cottonseed oil) consists of two main processes, the preparation and refining. Fig. (2.2) shows a flow diagram of edible oil processing[11].

Fig. (2.2): Processing of Oil (Cottonseed)



** Liquid wastes

The oil refining process may include the following steps:

- Neutralization.
- Washing.
- Bleaching.
- Deodorization.

These processing steps involve the reaction of oil with caustic soda and bleaching agents, which are halogenated compounds. Some of these chemicals remain in liquid waste, and when discharged with water, they act as source of pollution.

Neutralization, whether batch or continuous, refers to the removal of free fatty acids, phosphatides and other gross impurities by using caustic soda. Enough caustic soda must be added to neutralize completely the free fatty acids.

The neutralized oil is washed with hot water, and after settling any remaining soap solution is drawn off from the bottom. Most of the volume of liquid waste results from washing operations; the quantity of pollutants in liquid waste varies with the operation in refining process.

The pollutional characteristics of liquid waste in edible oil industry having readily definable effects on sewers and treatment plant are: volume, biochemical oxygen demand (BOD), suspended solids (SS) oil and grease, pH value, conductivity, and temperature.

2.2.2.2 Soap Manufacture:

Soap is formed by the reaction of neutral fats (triglycerides) and caustic alkaline (saponification process):

$$
\begin{array}{llll}
CH_2OOCR & & & CH_2OH \\
| & & & | \\
CHOOCR & + \quad 3NaOH & \longrightarrow & CHOH \; + \; 3\ R\text{–}COONa \\
| & & & | \\
CH_2OOCR & & & CH_2OH
\end{array}
$$

Triglyceride Caustic Soda Glycerin Soap

The soap maker is a large consumer of chemicals, especially caustic soda, salt, soda ash, and caustic potash, as well as sodium silicate, and sodium bicarbonate. Inorganic chemicals added to the soap are the so–called builders; tetra sodium pyrophosphate is effective synthetic soap builder(12).

Caustic soda and salt are the main pollutants in the soap industries, yet they could be recovered from the wastewater for reuse. Other chemicals pollutants are found in small amounts.

2.2.3 Soft–Drink Bottling Wastes

Soft–drink bottling wastes result from the production of non–alcoholic beverages, both carbonated and non–carbonated. The wastes are produced from washing of bottles, production of syrup, and treatment of water and washing of floors. They are usually highly alkaline, have a slightly higher BOD and suspended–solids content than domestic sewage, and are discharged to sewer with or without screening[7].

Bottle washing process consists of a series of alkaline detergent baths. The wastewater is highly alkaline. It contains suspended solids resulting from straws, paper, other refuse left in the bottle, and leftover drinks in dirty bottles. Thus pollutants are the major cause of the high BOD concentration.

Other operations contributing in water pollution are the cleaning of floors and syrup mixing, filtration and storing. These operations are not major sources of BOD and suspended solids.

To reduce the volume of waste, some plants reuse final rinse water from the bottle–washer for prerinsing dirty bottles.

The discharge of soft drink bottling wastewaters to municipal sewer system appears to be the best means of wastewater disposal.

2.2.4 Dairy Wastes

The preparation of pasteurized milk starts with the loading of raw milk at collection points in cans and then transporting it to processing plant. At the milk processing plant, the raw milk is dumped, sampled, weighed, clarified, filtered, preheated pasteurized, cooled, and poured into containers (e.g. glass or paper).

The waste–producing operations are washing and sterilizing of cans, tanks and other processing equipment, and floors. Milk–plant wastes are generally high in dissolved organic matter, contain about 1000 BOD, and nearly neutral or slightly alkaline(7). The wastes have the tendency to become acid quite rapidly, because of the milk sugar to lactic acid. Therefore, they respond ideally to treatment by biological methods.

2.2.5 Tannery Wastes

2.2.5.1 Source of Tannery Wastes

The leather industry comprises several production stages depending on the raw stock to be processed and the type of the end product. Fig. (2.3) shows a typical tanning processing steps. These stages can be summarized as follows[13,14].

a. Raw stock (Hides and skins): The tannery receives its stock (hides of skins) as green hides and skins directly from the slaughter house, or as frame dried and salt dried, or as wet salted. To preserve the stored stock against bacterial and insects attack, it is necessary to maintain good ventilation on the raw stock stores and to treat stock with certain insecticides and bactericides from time to time.

b. Liming and unhairing section: This section, known as the beam house, consists of two parallel sub–section, hide subsection and skin subsection. The main objective of this section is to remove the hair from hides and skins by the application of chemical and mechanical action. Chemicals used are a mixture of hydrated lime and sodium sulphide.

c. Tonnage Section: The tanning process can be divided into mineral tonnage and vegetable tonnage. Whereas in the first type mineral salts like basic chromium sulphate are used, in the second type vegetable tanning materials like mimosa and garad are used.

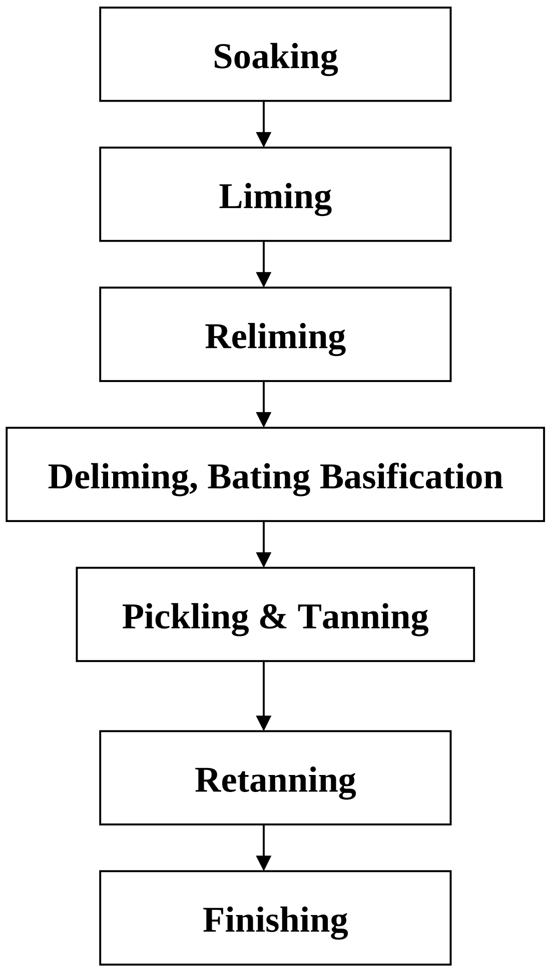
The mineral tonnage process is performed in the following sequence:

- Rinsing with cold running water.
- Deliming by application of ammonium salts.
- Bating by application of enzymatic bating agent.
- Pickling by application of salt + H_2SO_4.
- Chrome tanning by addition of basic chromium sulphate.
- Delining and pickling as in chrome tonnage.
- Pre–tonnage and tonnage with garad and mimosa, respectively.
- Fat liquoring by application of fat liquer.

d. Finishing section: In this section both hides and skins are finished for local market, and the sequence of operation includes conditioning, stacking, coloring, printing and ironing, fixing, embossing, final grading and measuring, and packing.

The tannery usually includes a wastewater system. The system consists of collection and draining trenches and a collection pit. A pre–treatment unit is necessary for reducing the pollution load in the wastewater.

Fig. (2.3): Typical Tonnage Processing Steps:



2.2.5.2 Characteristics of Tannery Liquid Wastes:

Tannery effluents are characterized by very high toxic organic and inorganic matter contents. The composition of tannery wastes vary with type of raw material used, process employed, product required, and raw water supply used(14).

In general the composition of tannery wastes contains large quantities of suspended and dissolved solids. The suspended solids include constituents such as hair, fleshes lime, hide scrap, manure, earth, calcium carbonate, and precipitate of lime and tannins(14).

The dissolved materials are organic as well as inorganic in nature, consisting of soluble proteins, starches, soda ash, oil and fats, caustic soda, ammonium sulphate, chromium salt, sulphonated oil, amines, sulphides, and dyes(16).

2.3 REDUCTION OF TOTAL POLLUTION LOAD IN INDUSTRIAL WASTEWATERS

The pollution loads of wastes discharged from existing industries could be minimized by:

- Volume reduction of such wastes, and/or.
- Waste strength reduction.

2.3.1 Volume Reduction of Wastes:

The volume reduction reduction of such wastes may be accomplished by reusing industrial effluents for raw water supplies or by the climination of batch or slug discharge of process wastes.

If any portion of final industrial effluent can be reused, there will be less waste to treat and dispose of. The reuse of industrial saves water and brings revenue into the city. On the other hand, the total dissolved solid (TDS) concentration is one of the chief limiting factors in reuse of any wastewater.

The discharge of a significantly higher volume and strength of wastes in a short period of time referred to as slug (sudden) discharge. This type of waste is troublesome to treatment plants. The reduction of the effects of these discharges is by increasing the frequency and lessening the magnitude of batch discharge.

2.3.2 Strength Reduction

The strength of wastes may be reduced by:

- Segregation of wastes.
- Equalization of waters, and
- Proportioning.

Segregation of wastes reduces the strength and/or the difficulty of treating the final waste from on industrial plant. The segregation results in two wastes; one particular strong process waste small in volume, and this can be treated according to the problem presented, e.g. recovered. The other waste is weaker process waste, with almost the same volume as the original un–segregated waste, and it renders the part of waste more amenable to treatment.

The equalization of waste is a method of retaining waste in a basin so that the effluent discharged is fairly uniform in its sanitary characteristics. Stabilization of pH and BOD and settling of solids and heavy metals are among the objectives of equalization. The size and shape of the basins vary with the quantity of waste and the pattern of its discharge from the factory. Most basins are rectangular or square tanks. Since almost all industrial plants operate on a cycle basis, an equalization tank to hold a cycle–period flow is sufficient.

Proportioning means the discharge of industrial wastewaters in proportion to the flow of municipal sewage in the sewers: In most cases it is possible to combine equalization and proportioning in the same basin. The objective of proportioning in sewers is to keep constant the percentage of industrial wastes to domestic–

sewage flow entering the municipal sewage plant. This will serve the following purposes:

- Protect municipal sewage treatment using chemicals from being impaired by a sudden overdose of chemicals contained in industrial wastes.
- Protect biological treatment devices from shock loads of industrial wastes, which may inactivate the bacteria.
- Minimize fluctuation of sanitary standards in the treated effluent.

The industrial wastes must be equalized and retained, then proportioned to the sewer according to the determine volume of domestic sewage flow.

2.4 TREATMENT OF INDUSTRIAL WASTEWATERS

The industrial waste is first pre – treated at the source to reduce the organic or inorganic matters either chemically or mechanically. The waste is then combined with the domestic waste for joint treatment at the municipal sewage system for complete treatment.

A conventional sewage treatment system consists of the following stages(16).

2.4.1 Preliminary Treatment

This is defined as conditioning of the industrial wastewater at its source before combining it with domestic waste for joint treatment. The purpose of this process is to remove recover, or neutralize substances that might be harmful for the subsequent biological depredation operation. Equalization of the wastes and proportioning also take place at this stage. Other materials such as rags, plastic, garbage, grit or grease are also removed.

2.4.2 Primary Treatment

At this stage industrial wastes are discharged in proportion to the flow of domestic sewage at the municipal sewage plant. The purpose of the stage is to remove large suspended organic solids and floating material, and to provide some partial removal of bacteria and viruses. This is usually accomplished by sedimentation in settling basins. Well–designed primary treatments remove about 60 percent of the influent suspended solids and 50% percent BOD(16). The organic matters, which are separated out in sedimentation tank, are stabilized by anaerobic digestion. The effluent from primary treatment plants can be used for irrigation of forestlands and crops such as cotton.

2.4.3 Secondary Treatment

The main objective of secondary treatment is to reduce the concentrations of dissolved and colloidal organic matter in wastewater. It also involves further treatment or oxidation of the effluent from primary treatment units. This accomplished through biological processes by filtration or activated sludge, oxidation ponds or other means.

Biological oxidation is the main methods of stabilizing the organic constituents of wastewater by means of micro–organisms. The bacteria convert the organic matter into their most highly oxidized organic form.

The effluent from the secondary treatment will contain low BOD and low suspended solids concentration. Effluents are disposed for irrigation purposes.

2.4.4 Tertiary Treatment

This represents the final or advanced treatment step, and is responsible for the removal of organic and inorganic constituents of the wastewater to levels below those achieved by primary and secondary treatment steps. It also achieves further removal of suspended solids, e.g. Algae, nitrogenous compounds, etc.

Tertiary treatment step may be physical, chemical, biological, or a combination of these operations, i.e. flocculation and sedimentation, flotation, micro–straining, and sand filtration are the most used operations.

Wastewater stabilization ponds represent the simplest process by which man attempts to stabilize the biodegradable matter contained in wastewater by creating favorable conditions for natural process of purification by considering the forces of nature, i.e. sunshine, wind, temperature, and spontaneous plant and animal life.

CHAPTER (III)

3. MATERIALS & METHODS

3.1 Introduction

This study has been carried out during the academic year 2001 – 2002 to cover the liquid waste of Khartoum North Industrial Area, its characteristics and appropriate methods of treatment and disposal.

Geographically, the industrial area extends from Kuber City Residential Area, about two kilometers to the North[(6)]. It is surrounded from the west by Khartoum North Railway Station and from the East by Kafouri City.

For the purpose of this study the major industries were grouped into four main sectors. The choice of these four sectors is based on their capacity, characteristic of wastes, and their contribution to the environmental pollution load. The four sectors chosen were:

1. Textile industries.

2. Food processing industries (sweets).

3. Oil mills and soap industries>

4. Soft drink.

3.2 MATERIAL

The final wastewaters from these sectors were studied to know the strength and volume of these wastewaters and hence the characteristics of wastewater of whole area, which is discharged to Elhaj Yousif treatment unit plant.

The amount of domestic waste required for joint treatment then be estimated for successful, and to avoid the collapse of this unit.

3.3 METHODS USED

1. Sites observations.

2. Data collections.

3. Interviews.

4. Laboratory liquid wastewater analysis.

5. Study of the waste treatment facilities.

3.3.1 Data Collection

The data was collected through field works in study area [Khartoum North Industrial Area & Alhaj Yousif Treatment Plant], and from visits to governmental departments such as:

1. Institute of research and of industries consulting.
2. Khartoum Municipality Council.

The field survey was carried out during research period; the main methods of data collection are:

a. Questionnaire designed.
b. General observations and visits.
c. Samples analysis.

3.3.2 Questionnaires

Questionnaires were designed to get the following information about the plants:

- Plant capacity and amount of wastewater disposed of.
- Characteristics of wastewater generated.

3.4 WASTEWATER ANALYSIS

3.4.1 Sampling

Points of sampling should be at last M.H. for industrial area. The collected samples were carried in glass bottles to the laboratory to determine the following characteristic.

BOD_5.

COD

PH

S.S

O & G.

BOD_5 was determined by applying the following methods depending on the type of industry and the expected wastewater concentration.

3.4.2 Methods for Determining BOD

METHOD 1:

Dilution of the wastewaters sample, effluents with high concentration or organic matter were diluted with oxygen rich deionised water (aerated by an air pump) in a one liter–measuring cylinder before being transferred to dissolved oxygen (DO) at determination bottles.

Procedure:

At each test volume of waste was surged and the dilution water was mixed in the graduated cylinder, with the aid of a glass rod. Three bottles (A_1, A_2, A_3) were filled with the water sample; one for the determination of the dissolved oxygen (DO) after 15 minutes and the other two bottles were incubated for 5 days at 20ºC.

Three other bottles (B_1, B_2, B_3) were filled with pure deionised water: one bottle for immediate determination of DO after 15 minutes and the other two bottles were incubated for 5 days at 20ºC. After the incubation period the DO of each bottle was determine.

Calculation:

$$BOD_5 = \left[\left(A_1 - \frac{A_2 + A_3}{2}\right) - \left(B_1 - \frac{B_2 + B_3}{2}\right)\right] \times \frac{1000}{V}$$

$A_1 \equiv$ The dissolved oxygen for the wastewater after 15 days incubation.

A_2 & A_3 ≡ the dissolved oxygen for the wastewater after 5 days incubation.

B_1 ≡ The immediate dissolved oxygen for the dilution water (blank test).

B_2 & B_3 ≡ The dissolved oxygen for the dilution water after 5 days incubation.

V ≡ The volume of waste.

METHOD 2:

Seeding the dilution water with micro organisms from aged wastewater, used usually for the analysis of industrial wastes to obtain proper BOD values.

SEED:

The seed material used was the supernatant liquid from a sample of domestic wastewater that had been allowed to age and settle in an open container for about 24 hours at room temperature. (Such seed is ready to work on wastes immediately). The amount of seed added to the dilution water was equal to the maximum amount recommended by the Rule of the thumb "is to add an amount of seed water such that 5 – 10% of total BOD exerted by the sample results from oxygen demand of the seed alone. For example when the sample size was 10ml, therefore is seeding only 10 percent of this amount was dissolved, that is 1.0ml of seed was added per one litter of dilution water".

PROCEDURE

Three bottles (A_1, A_2, A_3) were filled with the diluted sample of waste (waste = seed = dilution water); one for immediate determination of DO, and the other two for the determination of the DO after 5 days incubation at 200ºC.

To determine the BOD5 for the dilution water containing seed (blank test) three bottles (B_1, B_2, B_3), were filled with such water, and then proceeded as before. (The amount of seed added should not be necessary equal to 10% of the tested sample, it may be greater or less than this value).

Calculation:

$$BOD_5 = \left[\left(A_1 - \frac{A_2 + A_3}{2}\right) - \left(B_1 - \frac{B_2 + B_3}{2}.b\right)\right] \times \frac{1000}{V}$$

Where A_1, A_2, A_3, B_1, B_2, B_3 and V as described before.

B ≡ ratio of seed volume is seeded.

$$= \frac{\text{(Percentage or milliliter or seed in } A_1\text{)}}{\text{(Percentage or milliliter or seed of } B_1\text{)}}$$

Dilution water was prepared in accordance with procedure out line in standard methods:

(i) Chemical Oxygen Demand COD:

Analysis for the COD was run in accordance with the procedure given in standard methods. It is the measure of the oxygen equivalent of that portion of the organic matter in a sample that is susceptible to oxidation by strong chemical oxidant (i.e. profusion dichromate). The reagents were prepared, the analysis was carried out and the calculations were done according to techniques described in "the standard".

(ii) PH Value:

It is a term used to express the intensity of the acid or alkaline condition of a solution. It is a measure of the hydrogen–ion concentration or the hydrogen–ion activity. In wastewater treatment employing biological process the PH must be controlled within arrange favorable to the particular organism involved. It is measured using HACH direct reading DR/EL/2.

3.4.3 Physical Tests

(i) Total Solids (T.S.):

This refers to the matter that remains as residue upon evaporation and drying at 103 – 105C. It is determined by the evaporation and draying of a measured sample in a tarred container as described in the “standard methods”.

(ii) Suspended Solids:

It is a parameter used to evaluate the strength of the wastewater. It was measured as described in standard methods.

CHAPTER (IV)

4. RESULTS AND DISCUSSION

4.1 General

Khartoum North Industrial Area comprises more than 450 industrial plants (Fig. 4.1). About 47% of these plants were in operation, and 15% were idle. The industrial survey conducted in 1997 – 1998 revealed that the total number of factories in operation at that time were 381. The textile sector entailed 35 factories, food industries 150, paper mills and paper product unit 17, and chemicals 95 (Table 4.1).

The industrial wastes from these factories should be quantified and their strength be estimated in order to determine the proper proportioning of these waste to flow of municipal sewage in the sewer. This of course, would protect biological treatment devices from shock loads of industrial wastes and minimize fluctuations of sanitary standards in treated effluents. In doing so many considerations should be taken into account.

- Many of the factories are operating more of less seasonally, e.g. some edible oil mills, ethanol production from molasses distillery, etc.

- The production rates of the factories are fluctuating through the year due to many hindering causes such as financial difficulties, fluctuation in electricity supply, and instability of market demand. Hence, the quantities of industrial effluents released vary over the time depending upon these influencing factors.

- Slug discharge of process waste causes many troubles to treatment plants.

- The factories were not obliged or advised to pre–treat their wastewaters, and there is no organized waste management in the area. This led to frequent blockages of sewer system causing sewage flood with many harmful consequences.

Fig. 4.1: Status of Industrial Units in Khartoum North Industrial:

Table (4.1): Industrial Survey for the Year 1997 – 1998 for Khartoum North Area*:

No.	Sectors	In Operation	Idle	Total	% of Idle/Total	% of Sector/ Sectors
1.	Food	93	57	150	38%	39.3%
2.	Textile	19	16	35	45.7%	9.1%
3.	Wood & steel production	14	3	17	17.6%	4.46%
4.	Paper & paper production	19	1	20	5%	5.2%
5.	Chemicals	65	30	95	31.6%	24.9%
6.	Metal production	26	11	37	29.7%	9.7%
7.	Basic metallic industry	3	5	8	62.5%	2%
8.	Sector of metallic products machineries & equipment	11	8	19	42%	4.9%
	Total	250	131	381	34.4%	100%

* Source: Khartoum State Ministry of Industry (Industrial Survey 1997/1998).

These considerations made it very difficult to get good estimations of the amount and strength of industrial effluents discharged. However, the following steps were followed in getting reasonable estimations that led to minimization of the effects of industrial wastewaters on the treatment plant by the proportioning:

- Only the four sectors that use huge amounts of water have been selected for the study. The quantity of effluents from the rest of the sectors would be roughly estimated. The selection covered the sectors of textile industries, oil and soap industries, soft drink bottling and other food industries, and tanneries.

- In each of the selected sectors only those factories comprising wet processes came under close studies. The effluents from other factories were only estimated.

- Amounts of industrial effluents were either directly supplied by the factories or being estimated taking into consideration the plant capacity, operating time, and rate of production.

- The composition of the final effluents discharged was directly measured according the methods already discussed.

The sanitary characteristics determined include the following:

- BOD.
- COD.
- SS.
- PH.

The industrial sectors that came under investigation were considered in turn.

4.2 TEXTILE INDUSTRIES

In Khartoum North Industrial Area these are nineteen textile factories still working and discharge about 55,000 1/d. Table (4.2) shows the quantity of effluent discharged by each textile factory in the area.

There is no organized waste management in the area; each factory takes care of its own waste disposal. In fact no pre–treatment methods are applied by any of the factories to the effluents before being disposed to the sewage system.

4.2.1 Chemical Analysis of the Effluents

Table (4.3) shows the analysis of the combined effluent, discharged from five chosen factories at Khartoum North Industrial area. The analysis covered the following sanitary characteristics:

(i) BOD.

(ii) COD.

(iii) Total dissolved solids (TDS).

(iv) Suspended solids (SS).

(v) Copper (Cu).

(vi) PH value.

According to the industrial Waste Local Order 1971 for Khartoum North Council, the BOD value should not exceed 800mg/1 in industrial effluents discharged in to sewers. The values obtained from the factories in Table (4.3), ranging from 60 to 180mg/1, were far below the maximum permissible limits according to the local order. This due to the fact that the desizing operation, which is the main contributor to BOD value in the effluent has not been practiced in the factories being chosen. Also the scouring operation, which exerts high BOD value, is combined with the bleaching operation, and this resulted in low BOD value.

This is because the hydrogen peroxide (bleaching agent) is toxic to microorganism, resulting in less oxidation of waste and hence small BOD. The Star Knitwear Factory combined effluent possessed the lowest BOD value.

Table (4.2): Amounts of Textile Effluents in Khartoum North Industrial Area:

Name of Factory	Quantity of Effluent (L/d)
Bahry Textile Factory	2000
Star Knitwear Factory	4700
Ahlia Factory	4200
Al Hudhud Factory	3500
Nile Corporation for Textiles	15000
Sudanese Dyes Company	2800
Kameir Factory	1000
Khoagali Kintwear Factory	2000
Rest of the Factory	2000
Total	55,200

Table (4.3): Sanitary Characteristics of Combined Textile Effluents in Khartoum North Industrial Area:

Location Parameter	Nile Coorpor for Textiles	Star Knitwear Factory	Sudanese Dyes Company		Bahry Factory	Elhudhud Factory
			Before Septic Tank	After Septic Tank		
BOD	165	58	156	115	160	180
COD	510	62	282	156	3.80	420
TDS	1958	41	452	308	530	620
SS	3.87	3.60	4.26	3.16	3.80	4.30
Pb	0.10	0.08	0.08	0.0	1.3	1.5
Cu	0.09	1.0	1.2	1.2	2.02	2.3
pH	16.8	7.4	6.2	7.2	6.5	6.6

Values in mg/1 (except pH)

This was an expected result since the Kniting Factory uses no sizing materials.

The COD values in Table (4.3) range between 62 for Star Kntwear Factory and 510mg/1 for Nile Corporation for Textiles. The local order gives no permissible limits of COD, but still high values of COD are an indication of pollution because COD indicates the presence of organic matter.

The total dissolved solids (TDS) values were ranging between 41mg/1 at Knitting Factory and 1954mg/1 at the Nile Corporation for textiles. The high TDS value in the latter indicates that all the wet processing operations are practical there. Although nothing stated about TDS in the local order, yet high values are polluting.

Suspended solids (SS) value registered were all low showing that the textile industry does not entail much of suspended materials and that good house keeping is practiced, which also reduces the sanitary characteristics.

The value of copper (Cu) in all samples tested was ranging between 0.08 and 2.3mg/1. According to the local order, Cu value in the effluent discharged to sewers should not exceed 0.2mg/1. Comparing the values obtained to the maximum permissible value, it is found that, with exception of Nile Corporation for Textiles, all of them were much higher.

The pH value ranges between 6.2 and 10.2, which comply with the values obtained by the previous work undertaken. These range between 6.8 and 11.4. In the local order, the pH value should be in the range of 6.6 and 9.0. The values obtained in Table (4.3) showed that almost all effluents discharged were more or less neutral or slightly acidic.

Considering the analysis of the sanitary characteristics values obtained in Table (4.3) the following could be deduced:

- The textile factory in general and those chosen in particular are not operating at full capacity due to a number of reasons, mainly financial difficulties. This forced the factories to reduce the material used or drop some of the wet operations, e.g. desizing. Consequently the strength and quantity of waste discharged did not reflect exact values. Both were expected to be much higher at optimum operation conditions.

- The fluctuations in the sanitary characteristics of waste noticed at different times could be as a result of the following:

    - Batch–wise discharge of waste.
    - Absence of equalization operation of combined waste.
    - Instability in concentration of waste.

- Oil and grease are the floating materials removed in the desizing and scouring operations. The oil and grease contents were relatively small. Such small amounts create normally no problems in the sewage treatment plants. The plants are usually adequately designed to handle such grease bearing waste. It is possible to remove grease readily with surface skimmers in the primary clarifiers of a conventional sewage treatment plant.

4.2.2 Color Removal

Different types of dyestuffs are used in the textile industries, but the two main classes used are reactive and directs. Both classes exhibit relatively poor exhaustion properties that their dye wastes have residual color. Beside the color the reactive dye waste is highly alkaline as it contains caustic soda and soda ash.

The results of color removal experiments using activated carbon and fullers earth as adsorbents (with reactive and direct dye waste are shown in Table 4.4)(17).

The experiments were carried at 30ºC with three different concentrations of adsorbents, namely 5.10, and 15g/1. Samples for the color removal analysis were taken every 5 minutes. From these results the following could be deduced:

- For direct dye waste, the color could be best removed at room temperature, i.e. 30ºC. 15g/1 activated carbon gave 98% color removal, which is considered the best conditions since no extra heating is required.

- In the case of reactive dye the maximum percent color removal was attained by the addition of 15g/1 activated carbon to the dye waste.

Table 4.4: Color Removal by Activated Carbon:

(a) Direct Dyes

Activated Carbon Concentration g/1	% Color Removal		
	5min	10min	15min
5	87	93	94
10	93	95	97
15	98	98	98.2

(b) Reactive Dyes Direct Dyes

Activated Carbon Concentration g/1	% Color Removal		
	5min	10min	15min
5	68	74	79
10	80	82	85
15	87	90	90.5

4.3 EDIBLE OIL AND SOAP INDUSTRY

In Khartoum North Industrial Area oil is extracted from oil seed by mechanical pressing. The main oil seeds used are cottonseeds, groundnuts and sunflowers. The extracted crude oil is neutralized by caustic solution, and then washed with hot water, bleached, and finally deodorized.

The process–wastewaters are collected, together with floor washing water, in a settling well (gravity settling well or sedimentation well). The floating oil usually skimmed mechanically is recycled, and the final effluent is discharged to the sewer. The oil contents in the various sections are introduced in Table (4.5)[18].

Table (4.5): Percentage of Oil Content:

Sample	Max	Min	Mean
Cottonseed	22.5	20.2	21.33
Groundnut	47.4	32.9	40.5
Washing water	50.05	0.93	9.61
Sediment water	3.6	0.14	1.4
Final effluent	0.32	0.25	0.3
Soap stock	10.4	8.5	9.4
Soap sedimentation basin	33.2	4.8	15.5

For the oil content in the washing water, sedimentation tank, and final effluent, the values were 50%, 3.6% and 0.321%, respectively. According toe the industrial waste order 1971, the oil and grease content must not be above 150mg/1 (≈ 0.02%); this means it is far above the recommended limit.

The oil content in the soap stock is high, so the factory must make use of it by saponifying it with fresh fat or oil to reduce the content to the desirable limit.

The lower layer during soap making is water containing the colored bodies and other impurities from the oil. The material is recycled to fresh–fat reactors until the alkali is getting very low. This solution is used to recover a low–grade dark soap. The residual water is separated from soap, eventually neutralized and discharged to the sewer. In some factories the soap is separated in a settling vessel and the aquaus residue is settled in a skimming gravity basin, and the water is then discharged to the public sewer.

4.3.1 Characteristics of the Waste Water:

The average values of the characteristics are shown in Tables (4.6.1, 4.6.2, and 4.6.3) for the washing water, sedimentation water, and combined final effluent, respectively.

The values BOD from the results are 200, 130 and 310 mg/1 and the limit in the order is up to 800mg/1; i.e. the results are within the limits. The values of pH are 12.5, 12.8, and 8.45 as maximum, and 11, 16, 11.8, and 6.45 for minimum, where as according to the act no waste shall be allowed in the public below pH 5.5 or above 10.

The washing water and sedimentation water has to be treated before discharge to research the limits. For suspended solids the allowed value is 800ppm, and the obtained values are 3,600, 1000 and 3200 ppm respectively.

Together with cadmium there are three substances currently listed as toxic pollutants (Nickel, Zinc, and Phenols). Nickel has the potential of being present in the wastewater of plants that carry out hydrogenation of oil with Nickel as catalyst. In fact only one or two plants perform this operation. Zinc may potentially be present in wastewater from fat splitting (hydrolysis), many plants do not use zinc the hydrolysis operation. Phenols have been found in low concentrations in the effluent of oil refining plants.

The value of the COD obtained is very high, which means there are many organic compounds in the wastewater like gum, wax, phosphatides and other impurities that must be removed.

Table (4.6.1): Characteristics of Washing Water:

Parameter		Max	Min	Mean
BOD	Mg/1	200	25	105
COD	Mg/1	87,000	3500	2500
PH		12.5	11.16	11.88
TDS	ppm	64,000	3300	34,800
TSS	ppm	3,600	1560	2410

Table (4.6.2): Characteristics of Sedimentation Tank:

Parameter		Max	Min	Mean
BOD	mg/1	130	40	83
COD	mg/1	94,800	14,700	53,100
PH		12.84	11.8	11.8
TDS	ppm	33,700	16,500	25,400
TSS	ppm	1000	890	950

Table (4.6.3): Characteristics of Combined Final Effluent:

Parameter		Max	Min	Mean
BOD	mg/1	310	65	185
COD	mg/1	42,300	900	19,900
PH		8.45	6.45	7.3
TDS	ppm	24,700	12,800	19,300
TSS	ppm	3200	2800	300

Amount of Wastewater Discharged

Khartoum North Industrial Area comprises about 18 edible oil plants and 17 soap factories. The oil plants can be classified with two categories, large plant with crushing capacity wore than 50 tons of seeds per day, and small plants with capacity less than 50 tons. Table (4.7) presents the amount of effluent disposed of from the oil and soap industries.

Table (4.7): Characteristics & Amount of Effluent Discharged:

Description/Parameter	Large Oil Plants	Small Oil Plants	Soap Factory
- Number off	4	14	17
- Capacity t/d (Crushing/Soap)	200,000	240.000	290
- Quality Wastewater, m^3/d	60	83	42.5
BOD mg/1	200	200	400
COD mg/1	30.000	30.000	50.000
TDS ppm	20.000	20.000	70.000

The above values and calculations have taken the following considerations into accounts:

- The plants are operating at capacities about 50% or less.
- Good house keeping is always considered.
- Segregation and recovery of dissolved materials in wastewater should be one of goals for pollution prevention.

- Processes and operations are similar for all plants in each category.

Soft–Drink Bottling Wastes

There are four soft–drink bottling factories in Khartoum North Industrial Area, namely Crystal Industry, Mamoun Elberier Bottling Factory, Coca Cola, and Pepsi Cola Factories. Depending on the type of soft drink and type of bottles used, the water used could classify as follows:

- Process water (feed water + boiler water).
- Washing (bottles and floors).
- Cooling water.
- Drinking water.

The wastewaters are those resulting from washing of bottles and floors and sanitary wastewater. The combined effluents are alkaline consisting of hot/cold water, caustic soda and detergents. Table (4.8 and 4.9) shows the estimated effluents and their sanitary characteristics, respectively.

Tables (4.8): Estimated Effluents Amount:

Factory Name	Estimated Effluent M^3/yr
- Crystal Factory	72,900
- Mamoun Elbereir, Bottling Factory	62,400
- Coca Cola Factory	112,400
- Pepsi Cola	87,200
Total	334,900

Table (4.9): Strength of Wastewater:

Factory Name	BOD ppm	TS ppm	pH
Crystal Industry	22,000	43,000	3.4
Mamoun Elbereir Factory	65,000	105,000	9.0
Coca Cola Factory	67,400	114,900	10.2
Pepsi Cola Factory	79,500	122,000	10.0

4.5 DAIRY WASTES

There are three factories in operation, namely Kuku Milk Factory, ACAPP Dairy Unit, and Premier Food Products (Daima). Kuku Milk Factory produces mainly pasteurized milk, while the other two factories produce milk and yoghurt. The estimated amounts of disposed effluents and their strength are presented in Table (4.10).

Table (4.10): Strength of Dairy Waste:

Factory Name	Amount of Effluent M^3/yr	BOD ppm	pH
Kuku Milk Factory	15,000	1000	10
ACAPP Dairy Unit	22,000	900	8.7
Premier Food Products	26,000	830	8.2
Total	63,000	895	8.8

4.6 Sweets Factories Wastes

The products of the sweet factories in Khartoum North Industrial Area are listed in Table (4.11).

Table (4.11): Products of Sweet Factories:

Factory	Products
Rea Sweet Factory	Toffees, Halawa Tahinia
Kribab Sweet Factory	Toffees, Jam
Mamoun Elbereir Factory	Toffees, Halawa Tahinia
El Musharaf Factory	Halawa Tahinia
Saeed Factory	Jam, Tomato Paste

The waste produced by the toffees manufacturing are the splits on the floor and washing of the floor. Manufacturing of Halawa Tahinia uses much water and salt. The wastewater is saline water with high content of suspended solids. Manufacturing of jam and tomato paste requires much quantities of water for washing of fruits and vegetables and for washing of floor. The wastewater is high in dissolved organic matter and almost neutral or slightly acidic. Table (4.12) presents the amount of wastewater produced and its constituents.

Table (4.12): Strength of Sweets Factories Wastewater:

Factory	Wastewater M^3/gr	BOD ppm	TS	pH
Rea Sweet Factory	9500	67,000	120,000	7.8
Kribab Sweet Factory	8400	45,000	87,000	6.7
Mamoun Elbereir Factory	10,120	80,000	150,000	7.8
El Musharaf Factory	8800	175,000	200,000	7.8
Saeed Factory	12200	103,000	95,000	5 – 7

4.7 TANNERY WASTEWATERS

A fro–star is the only tannery in Khartoum North Industrial Area with a capacity of 500 skins and 500 hides. The skins and hides are processed to the stage of wet blue, i.e. tanned with basic chromium sulphate. The tannery effluent has the following characteristics:

- Amount of wastewater = m^3/yr.
- BOD.
- TS.
- Ph.

4.8 TOTAL WASTEWATERS FOR INDUSTRIAL AREA

The amounts of industrial wastewater and sanitary wastewater from the different sectors are presented in Table (4.13). The pollution loads of industrial area are also included,

TABLE (4.13): Strength Total Wastewaters for Industrial:

Sectors	Wastewater M^3/yr	BOD ppm	TS	PH	COD
Textiles	16,560	140	650	6.7	240
Edible oil and soap	250,500	300	34.800	11.9	2500
Soft drinks	334,900	58,800	96,200	8.2	–
Dairy	63,000	895		8.8	–
Sweets factories	49,020	94	130,600	7.4	–
Other sectors	100,000			500,000	

4.9 JOINT TREATMENT OF INDUSTRIAL AND DOMESTIC WASTEWATERS

Table (4.13) shows that the sanitary characteristics of the industrial effluents are very high for all industrial sectors. The effluents are discharged through a pipe–network into the sewage treatment plant, which is suitable 8km to the east. The treatment plant has a design capacity of 6MGD (about 22,630m^3/d ≈ 7,570,000m/yr), this capacity was originally planned for joint treatment of industrial waste and domestic sewage from Kober residential area.

The treatment plant has been designed the combined wastewater, through primary treatment and secondary treatment by means of stabilization ponds. In general the plant consists of the following units and devices:

- 2 force mains, asbestos cement of 16 inch and 18 inch discharging raw effluent into the plant.
- 2 sets of screens, 1 aerated grit chamber.
- 2 circular clarifiers with sludge discharging line into 2 digesters.
- Sludge drying beds.
- Stabilization ponds.
- 4 anaerobic ponds.
- 4 facultative ponds.
- 2 maturation ponds.

4.9.1 Combined Industrial Wastes

For the treatment of the industrial wastewaters at the treatment plant, the following assumptions are to be considered:

- The sanitary characteristics of the industrial effluents will not or slightly altered during the joining to the treatment plants.

- The average values of the sanitary characteristics will be the arithmetic mean per unit volume.

- Table (4.14) presents the total industrial amount discharged and its characteristics.

Table (4.15): Combined Industrial Wastes:

Description	Values of Composite Samples					Average Values
Total wastewater discharged m3/yr	819,580					819,580
BOD ppm	5700	10,000	6400	1250	2750	5220
COD ppm	9200	2800	7000	8000	3500	8100
Oil & grease	868	459	1381	2194	726	1126
TS	580	617	1103	570	450	664
pH	7.2 ——————— 6.5					6.9

Table (14.4) show that there are very wide variations in the sanitary characteristic from day to day depending on the type of the industrial sectors and amount of waste discharged on that particular day. The average values were taken at arithmetic mean of the composite samples.

It is noticeable that the COD showed particularly high values. On the other hand, the values for BOD of the composite samples, with exception of soft drinks and sweet factories, were for above those registered for other industrial sector in Table (4.13). The combined industrial is almost neutral; the pH range between 6.5 – 7.2 (Table 4.14).

4.9.2 The Domestic Waste

The available sanitary characteristics of domestic wastes were given in Table (5.14). Other characteristics have not been measured during the period of preparing this work.

Table (4.15): Sanitary Characteristics for Domestic Wastes:

Characteristic	Values
BOD	448
S.S	550
T.D.S	503

4.9.3 Joint Treatment of Industrial and Domestic Wastes

Comparing the characteristic of both industrial and domestic wastes in Table (4.14) and (4.15) respectively, the following could be deduced:

- The domestic wastes are biological nature biodegradable, and characteristic values are low compared to industrial one.
- Combining both results will reduce the characteristic value of the combined wastes substantially to the permissible levels. Further more, the combination makes the industrial waste more amenable to biological treatment.
- Reduction of the industrial characteristic values will be at the cost of addition of more domestic wastes.
- Estimating that the family in Kobar District will be consisting of 5 person on the average, and that the waste water discharged per–person is about "7501/d".
- To achieve the industrial waste with biodegradable material, a considerable amount of the domestic waste has to be added. In sewering the residential area of Kobar town to the treatment plant, phase tow well be ended and the plant should operate in the proper manner.

CHAPTER (V)

5. CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The study was carried out on the attempt of joint treatment of industrial and domestic wastewater. The majority of industrial wastes are amenable to biological treatment after; dilution with domestic wastewater. Also industrial waste can be treated to reduce the organic or inorganic solids prior to disposal in a municipal plant.

The study area consists of Khartoum North Industrial Area, and Al Hag Yousif treatment plant. There are more than 300 industrial plants including food industries, textiles paper and paper products, dairies, chemical industries, etc. The plant has a design capacity of 6MGD.

The objectives of the study were the determination of the quantity and strength of main industries wastewaters in Khartoum North Industrial Area and the calculation of waste strength for the joint treatment of industrial and domestic wastes.

The composition of the final effluents discharged from industrial plants was measured and the sanitary characteristics determined include the BOD, COD, SS and PH. The results revealed the following conclusions:

- Only about 47 percent of industrial plants comprised by industrial area were in operations, and those operate at capacities lower then design capacities due to a number of reasons, mainly financial and marketing difficulties.
- The sanitary characteristics of textile, industries–wastes, are with the values recommended by the industrial waste local order 1971 for Khartoum North Council. This is because most of the factories reduce the quantity of chemical used or drops some of the wet operations (e.g. Desizing), and consequently the strength and quantity of waste discharge did not reflect exact values.
- Oil and soap industries contributions of sanitary characteristic are high composed to other industries due to the large number of installed plant in the area.
- The oil content in the final effluent, about 0.32% is far above the value recommended by the industrial waste order, 1971 of approx. 0.02%. The values BOD are within the limits in the order, which the obtained suspended solid

values are high above the allowed values. The values of the COD obtained are very high which means there are many organic compounds in the wastewater like gum, wax, phosphotides and other impurities that must be removed.

- The final effluent from soft drink bottling is alkaline consisting of caustic soda and detergents and amounts to approx. 335,000m^3 per annual. The sanitary characteristics BOD and TS are high above the allowed values.

- The dairy wastes amount to 63000m3/yr with BOD values of Ca 900ppm.

- Confecturay factories (Toffee and Halawa Tahinia) produce saline wastewaters with high content of suspended solids.

- The amount of industrial wastewaters from different sectors is about 819,580m^3 with average values of sanitary characteristics BOD $\approx$ 5220ppm, TS $\approx$ 664ppm. Combin–ing these wastes with domestic wastes from residential areas will definitely be amenable to biological treatment.

5.2 RECOMMENDATION

- All industrial sectors should be obliged to pre–treat their wastewaters leading to the reduction of strength and volume of wastes. This includes segregation, recovery, proportioning, etc.
- Promote cleaner and cost efficient technologies all stages of the different processes and waste management.
- Develop fair and implement able environmental legislation. The proper protection of clean environment should be based on solved understanding the chemistry and the risks associated with particular pollutants resulting from the different industries.

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